

What is claimed is:

1           1.       A method for removing contaminants from the surface of a substrate which  
2 comprises applying a fluid to the surface; lowering the temperature of the fluid so as to form  
3 a solid layer of the fluid over the surface and entrapping contaminants within the layer; and  
4 applying energy to the layer or substrate or both under such conditions as to result in  
5 separation of the layer including the contaminants from the surface.

1           2.       The method of claim 1 wherein the substrate is a semiconductor substrate.

1           3.       The method of claim 1 wherein the substrate is a silicon substrate.

1           4.       The method of claim 1 wherein the contaminants comprise silicon, silicates,  
2 silicon dioxide, metals, metal oxides, organic materials, and bacteria.

1           5.       The method of claim 1 wherein the fluid comprises water.

1           6.       The method of claim 5 wherein the water is deionized water.

1           7.       The method of claim 1 wherein the energy is applied to the layer.

2           8.       The method of claim 1 wherein the energy is applied to the substrate.

3           9.       The method of claim 1 wherein the fluid is applied at ambient conditions.

1           10.      The method of claim 1 wherein the temperature of the fluid is lowered by  
2 directly reducing its temperature.

1           11.      The method of claim 1 wherein the temperature of the fluid is lowered by  
2 employing a cryogenic gas in the solid or liquid phase.

1           12.      The method of claim 11 wherein said cryogenic gas comprises nitrogen.

- 1 13. The method of claim 11 wherein said cryogenic gas comprises carbon  
2 dioxide.
- 1 14. The method of claim 1 wherein the energy is sonic energy.
- 1 15. The method of claim 14 wherein the sonic energy is applied to the layer.  
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- 2 16. The method of claim 14 wherein the sonic energy is applied to the substrate.
- 1 17. The method of claim 1 wherein heat energy is applied.
- 1 18. The method of claim 17 wherein the heat energy is applied to the substrate.
- 1 19. The method of claim 1 wherein the temperature of the fluid is lowered by  
2 reducing the temperature of the substrate.
- 1 20. The method of claim 19 wherein the temperature of the fluid is lowered by  
2 employing a cryogenic gas in the solid or liquid phase.
- 1 21. The method of claim 20 wherein said cryogenic gas comprises nitrogen.
- 1 22. The method of claim 20 wherein said cryogenic gas comprises carbon  
2 dioxide.
- 1 23. A method for removing contaminants from the surface of a substrate which  
2 comprises applying a fluid to the surface; lowering the temperature of the fluid by reducing  
3 the temperature of the substrate so as to form a solid layer of the fluid over the surface and  
4 entrapping contaminants within the layer; and applying sonic energy to the layer or substrate

5 or both under such conditions as to result in separation of the layer including the  
6 contaminants from the surface.

1 24. The method of claim 23 wherein the substrate is a semiconductor substrate.

1 25. The method of claim 23 wherein the substrate is a silicon substrate.

1 26. The method of claim 23 wherein the contaminants comprise silicon, silicates,  
2 silicon dioxide, metals, metal oxides, organic materials, and bacteria.

1 27. The method of claim 23 wherein the fluid comprises water.

1 28. The method of claim 27 wherein the water is deionized water.

1 29. The method of claim 27 wherein the fluid is applied at ambient conditions.

1 30. The method of claim 23 wherein the sonic energy is applied to the layer.

1 31. The method of claim 23 wherein the sonic energy is applied to the substrate.

1 32. The method of claim 23 wherein the temperature of the fluid is lowered by  
2 employing a cyrogenic gas in the solid or liquid phase.

1 33. The method of claim 32 wherein said cyrogenic gas comprises nitrogen.

1 34. The method of claim 32 wherein said cyrogenic gas comprises carbon  
2 dioxide.